



Translation of PCT Case WO 98/04381

**Method of joining a plasticisable workpiece  
to another workpiece**

The invention relates to a method of connecting or jointing a plasticisable workpiece to another workpiece, which may also be plasticisable, i.e., for example, two or more plasticisable and particularly metal workpieces.

The invention also relates to a friction element and an apparatus for performing the method according to the invention.

Various jointing techniques for plasticisable or metal workpieces on the basis of a welded joint are already known. Depending on the range of application, particularly in the connecting of (aluminium) thin sheets, the known jointing techniques have serious disadvantages inasmuch as they are extremely cost-intensive, require complex equipment or else a special material preparation is required, and even then many material combinations are practically impossible to join together.

The object of this invention is to provide a method of connecting or jointing a plasticisable or metal workpiece to another without the said and other disadvantages.

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To this end, according to the invention, a method of joining a plasticisable workpiece to another workpiece, is characterised in that

(a) a first workpiece is pressed against a base workpiece, a jointing zone being located between the first workpiece and the base workpiece,

(b) a friction element is pressed against the first workpiece with activating relative movement with respect to the workpieces in the direction of the jointing zone,

(c) the friction element advances through the first workpiece as far as the base workpiece with the formation of an activated plasticised process zone and brings the latter into the region of the jointing zone,

(d) the friction element is withdrawn, a friction welded band being produced between the workpieces in the region of the jointing zone.

Advantageous embodiments of the invention are described in the sub-claims.

The jointing zone of the workpieces forms in these conditions by a mechanism which is similar to that of the jointing operation known from friction welding. By creating a highly active high-energy and also mechanically mixed process zone in the connection zone of the two workpieces it is possible

to join together metals or alloys which were hitherto considered as difficult to join together, if at all, as in the case, for example, with thin aluminium sheets, in which the oxide layer is very obstructive.

With regard to the apparatus, the invention is characterised by a friction element and apparatus for performing the method according to the invention.

Due to the activation or heat generation by friction, the friction element preferably in the form of a rotating punch forms an annular wall of partially or completely melted material which is introduced, by the pressure of the punch and by centrifugal and capillary forces, uniformly into the joint between the workpieces and into the gap between the punch peripheral surface and the surrounding material.

Amongst the advantages of the method according to the invention particular mention should be made of the fact that it dispenses with the use of additional welding aids such as additional welding material or combustion gases. Consequently, the connection zone between the workpieces consists solely of the material of the workpieces themselves. The method according to the invention can also be performed without the use of electric power, since a corresponding apparatus is operated with compressed air for example. Also, in contrast with the known electric or spot welding, there is practically no spark evolution.

The method according to the invention is described in detail hereinafter with reference to one exemplified embodiment and a workpiece bond produced according to the invention and with reference to the drawings wherein:

Figs. 1 to 5 are cross-sections of two workpieces in consecutive phases of making the workpiece bond and

Fig. 6 shows a bond consisting of three workpieces in cross-section.

Figs. 1 to 4 illustrate the production of a workpiece bond according to the invention as shown in finished form in Fig. 5. Fig. 1 shows two superposed workpieces 1 and 2 in the form of plates which, for example, may be metal sheets or parts of hollow profiles for joining together. The two parts are firmly pressed against one another but it is not necessary to give the surfaces of the workpieces 1 and 2 special treatment in the region of the joint or contact zone 3, nor remove rolling or oxide skins or the like, as is necessary with spot welding, since the jointing mechanism is completely different.

All that is required is for one of the workpieces for jointing to be plasticisable or meltable, as shown by tests with ceramics as a participating material. Apart from metals, plastics are also usable.

A rotating punch 4 is moved against the surface of the workpiece 1 and pressed firmly against it while maintaining the rotation (Fig. 2). The punch is rotated by a drive unit (not shown). The punch can consist of the same material as the workpieces 1 or 2 but is preferably made from a harder and/or higher-melting material. To prevent material of the workpieces 1 and 2 from temporarily sticking to the punch during the friction welding process, the punch 4 can also consist of hard metal or have a special coating.

During the subsequent friction welding operation, a physico-chemically highly-active process zone forms between the rotating punch 4 and the material in contact therewith, and dry friction and then mixed friction occur in this zone. In the mixed friction zone the proportion of dry friction decreases and that of the liquid friction increases. Individual melt islands form in the region of the process zone and reach the peripheral or edge zone of the punch partly as a result of centrifugal force and partly as a result of the punch contact pressure and form a material accumulation 5 in the form of a bead there (Fig. 3). The peripheral zone of the punch 4 which has already penetrated partly into the workpiece 1 is increasingly filled by plasticised or melted material.

Compared with the state shown in Fig. 3, the punch is advanced in the direction of the base workpiece 2 until at least its endface is situated in the

contact plane or jointing zone, preferably somewhat further into the base workpiece 2 as shown in Fig. 4. This takes place so that the quantity of melted or plasticised material displaced by the penetration of the punch into the base workpiece 2 is at least partially pressed into the gap between the two workpieces as shown by reference 6 in Fig. 4. The penetration of the material into this region of the jointing zone is assisted on the one hand by centrifugal force due to the rotation of the punch and on the other hand by the capillary forces in the gap. The punch is also surrounded along its peripheral surface by a layer of at least partially melted material.

At its periphery the punch can be provided with a cutting device to ensure that the bead 5, which does not contribute to the strength of the joint, is immediately removed.

The punch is then withdrawn from the jointing zone, the workpiece bond shown in Fig. 5 remaining. During the jointing operation a cylindrical and substantially rotationally symmetrical connection zone 4 in the form of a sleeve or after the style of a hollow rivet is produced between the workpieces. This consists solely of the materials of the participating workpieces if the punch is harder or higher-melting, while as a result of the specific properties of a friction welded joint it is possible to join together even very different materials which conventionally it would be practically impossible to

connect, for example aluminium sheeting or steel and aluminium.

As shown in Fig. 6, the method according to the invention can also be applied to more than two workpieces, while in the example illustrated two workpieces 1 and 1a are disposed on a base workpiece 2 and the friction punch completely penetrates the two workpieces 1, 1a. In a modification, two friction punches operating in opposition can be used on both sides of the workpiece bond and be advanced towards one another. As a result, a device for supporting the workpieces or for taking the transmitted force would be unnecessary.

A device (not shown) for performing the method according to the invention is described in claims 12 and 13. Since the heat evolved by the rotation or relative movement of the friction element in relation to the workpieces decreases with increasing plasticisation of the material and hence a decrease in the coefficient of friction, it is advantageous to provide a speed control system for the friction punch in dependence on the feed path or speed and/or the contact pressure. In this way it is possible to obtain optimum and reproducible material temperature during the jointing operation, and also the time required to make a joint can be minimised.

The features of the invention disclosed in the above description, in the drawing, and in the claims may be important to embodiment of the invention in its

various forms both individually and in any combination.

**C L A I M S**

1. A method of joining a plasticisable workpiece to another workpiece, characterised in that

(a) a first workpiece (1) is pressed against a base workpiece (2), a jointing zone (3) being located between the first workpiece (1) and the base workpiece (2),

(b) a friction element (4) is pressed against the first workpiece (1) with activating relative movement with respect to the workpieces (1, 2) in the direction of the jointing zone (3),

(c) the friction element (4) advances through the first workpiece as far as the base workpiece with the formation of an activated plasticised process zone and brings the latter into the region of the jointing zone (3),

(d) the friction element is withdrawn, a friction welded bond being produced between the workpieces (1, 2) in the region of the jointing zone (3).

2. A method according to claim 1, characterised in that two or more workpieces (1, 1a) are disposed one above the other on a base workpiece (2), the friction element (4) penetrating all the workpieces (1, 1a) successively.

3. A method according to claim 1 or 2, characterised in that the first workpiece (1, 1a) is a thin metal sheet.

4. A method according to any one of the preceding claims, characterised in that the base workpiece is a thin metal sheet.

5. A method according to any one of the preceding claims, characterised in that the friction element consists of a rotating punch.

6. A method according to any one of the preceding claims, characterised in that the friction element performs a linear oscillating movement.

7. A method according to any one of the preceding claims, characterised in that the friction element consists of a material which has a higher melting point than the workpiece (1).

8. A method according to any one of the preceding claims, characterised in that the friction element consists of a material which is harder than the workpiece (1).

9. A method according to any one of the preceding claims, characterised in that at least one of the workpieces (1, 1a, 2) consists of aluminium or an aluminium alloy.

10. A method according to any one of claims 2 to 9, characterised by another friction element which is pressed against the workpieces from the side remote from the first friction element.

11. A method according to any one of claims 2 to 9, characterised by two or more workpieces on either side of a base workpiece (2).

12. A friction element for performing the method according to any one of claims 1 to 11, characterised in that the friction element is substantially cylindrical and has a cutting means for removing the bead (5).

13. Apparatus for performing the method according to any one of claims 1 to 11 comprising

a holder unit for holding at least two workpieces,

an axially displaceable clamping unit adapted to be driven and rotated about a rotational axis, for clamping a friction element,

a speed-controllable drive unit for driving the clamping unit,

a displacement unit for moving the clamping unit along the rotational axis and pressing the friction element into contact with a contact pressure.

14. Apparatus according to claim 13, characterised by means for detecting the speed, displacement and/or contact pressure and a control device for controlling the speed of the friction element in dependence on the recorded values of the detected displacement and/or contact pressure.